MACSUR – TradeM workshop Oslo, Nov, 25 – 27, 2014

AWARENESS OF CLIMATE CHANGE FOR ADAPTATION OF THE FARM SECTOR

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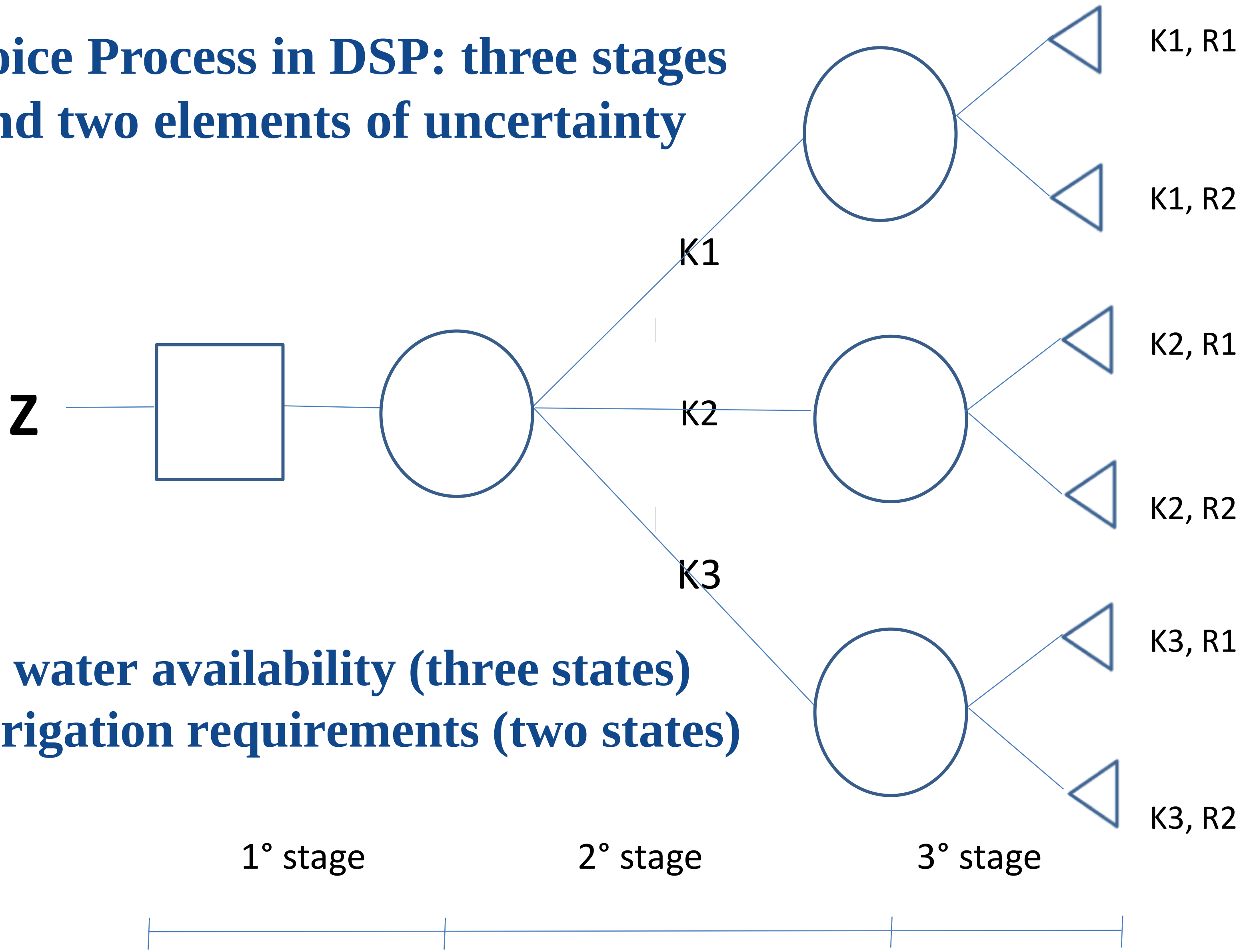
- **1. Discrete Stochastic Programming for simulating farm management as prone to inherent variability of climate**
- **2. Study area and simulated impacts of transition from *current* to *future* climate scenario.**
- **3. Focus on the *current* climate variability by simulating three hypothesis on the actual cognition of farmers about it:**
  - **farmers assuming that climate is stable,**
  - **farmers assuming that climate is changing and update their cognition based on weather observations,**
  - **farmers perfectly knowing the actual climate variability.**

Part 1: The DSP decision-making process

- **Farmers' expectations represented by probability distribution functions (PDF) of the uncertain variables, discretized in states of nature (*not many*),**
- **Each *state* of the uncertain variable generates:**
  - **Optimal Result** when it is *preferred*, and actually occurs;
  - **Sub-Optimal Results** when other, *not preferred* states occur.
- **States are evaluated based on probability, and on possibility of correcting choices when sub-optimal conditions occur in the course of the actions,**
- **Farmer plans the activity based on the state with the highest expected income w/r to optimal and sub-optimal conditions.**

Choice Process in DSP: three stages and two elements of uncertainty



water availability (three states)
irrigation requirements (two states)

DSP model (variable crops and milk yields, and water needs)

- $\max_{x, za_s, zy_s} z_{dsp} = \sum_s \boldsymbol{P_s} * (GI_s * x - Cza * za_s - Czy * zy_s)$
- subject to
- $A * x \leq B$
- $A_s * x \leq B + za_s \quad \forall s$
- $N * y_s * x + zy_s \geq R \quad \forall s$
- $x \geq 0, \quad za_s \geq 0$ and $zy_s \geq 0 \quad \forall s$

- z_{dsp} expected total gross income; P_s probability s states of nature; GI_s gross income of x activity and s; Cza and Czy costs of za_s zy_s adaptation action for s; A matrix of technical coefficients and B resources availabilities; A_s matrix of technical coefficients for s; N matrix of feed nutritional content; y_s yields of forage crops in s; R nutrient requirements.

- **PDFs as farmers' expectations on agro-climate variability. PDFs divided into three states of nature with constant probability in all the climate scenarios (low = 25%, mean = 50%, high = 25%), changing the values that represent them.**

- **DSP takes probability of states of nature, and possibility of corrective actions when unplanned states occur:**
  - Irrigation requirements higher than expected: draw more water from wells, but at not budgeted costs.
  - Forage yields lower than expected: purchase animal feed, with additional costs related to the market prices.
  - Price variability of the final product <u>is not</u> a DSP problem when no corrective action can be taken

- **Corrective actions have a cost that varies with the scenario of climate variability faced by the farmer**

- **DSP allows simulating choices of farmers under different climate scenarios, precisely, with different climate variability**

Part 2: Study area and basic simulations

- **A Hybrid DSP model (area and 13 farm types) representing the farm sector in Oristano province - west Sardinia, Italy**

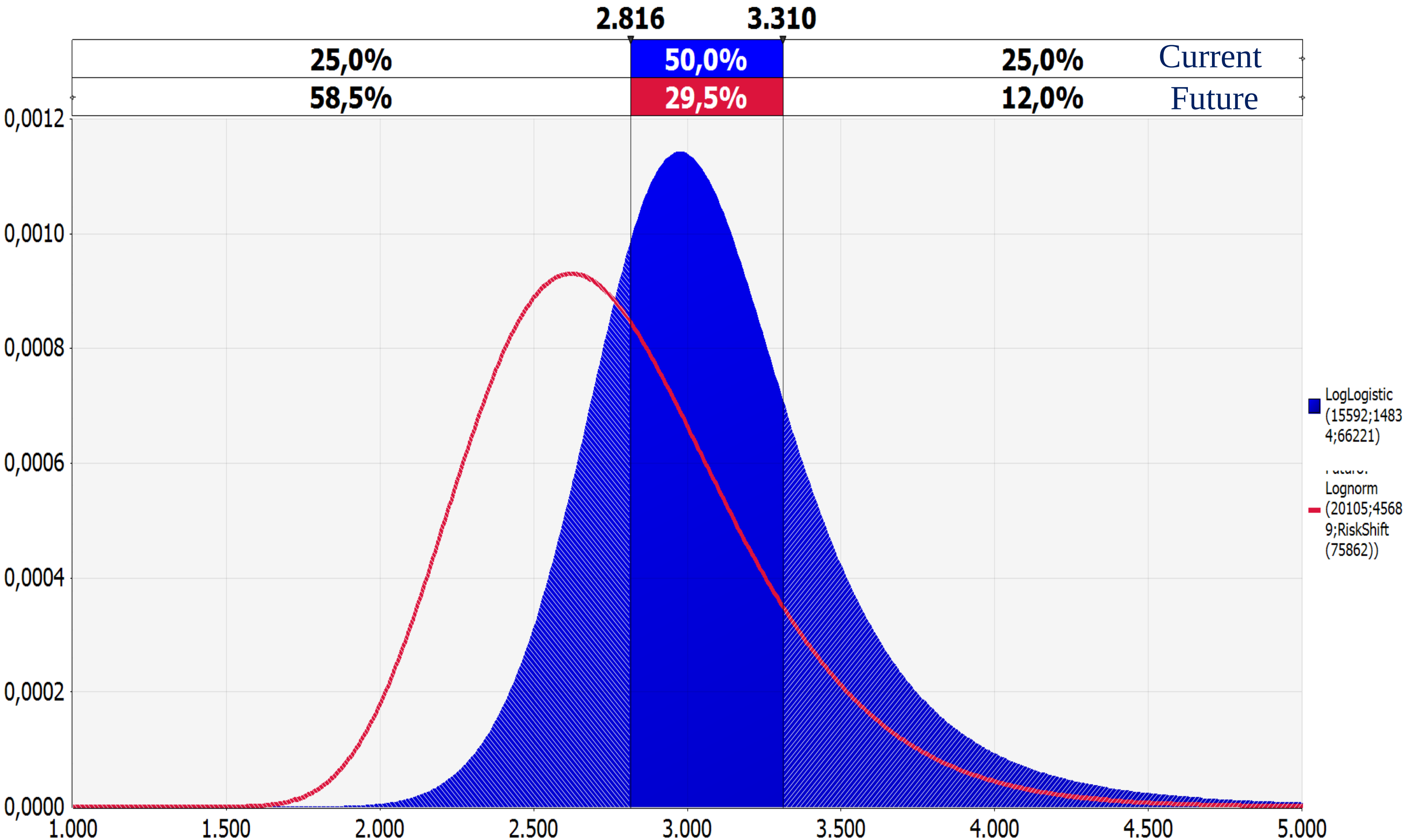
- **The model is PMP calibrated over actual 2010 use of soil under a *current climate* obtained by a climatological model (RAMS) based on 2000-2010 atmospheric physical states.**

- **Productive (from EPIC, DSSAT, livestock models) and income results at *current* RAMS compared to results under 2020-2030 RAMS to estimate impacts of transition to future climate.**

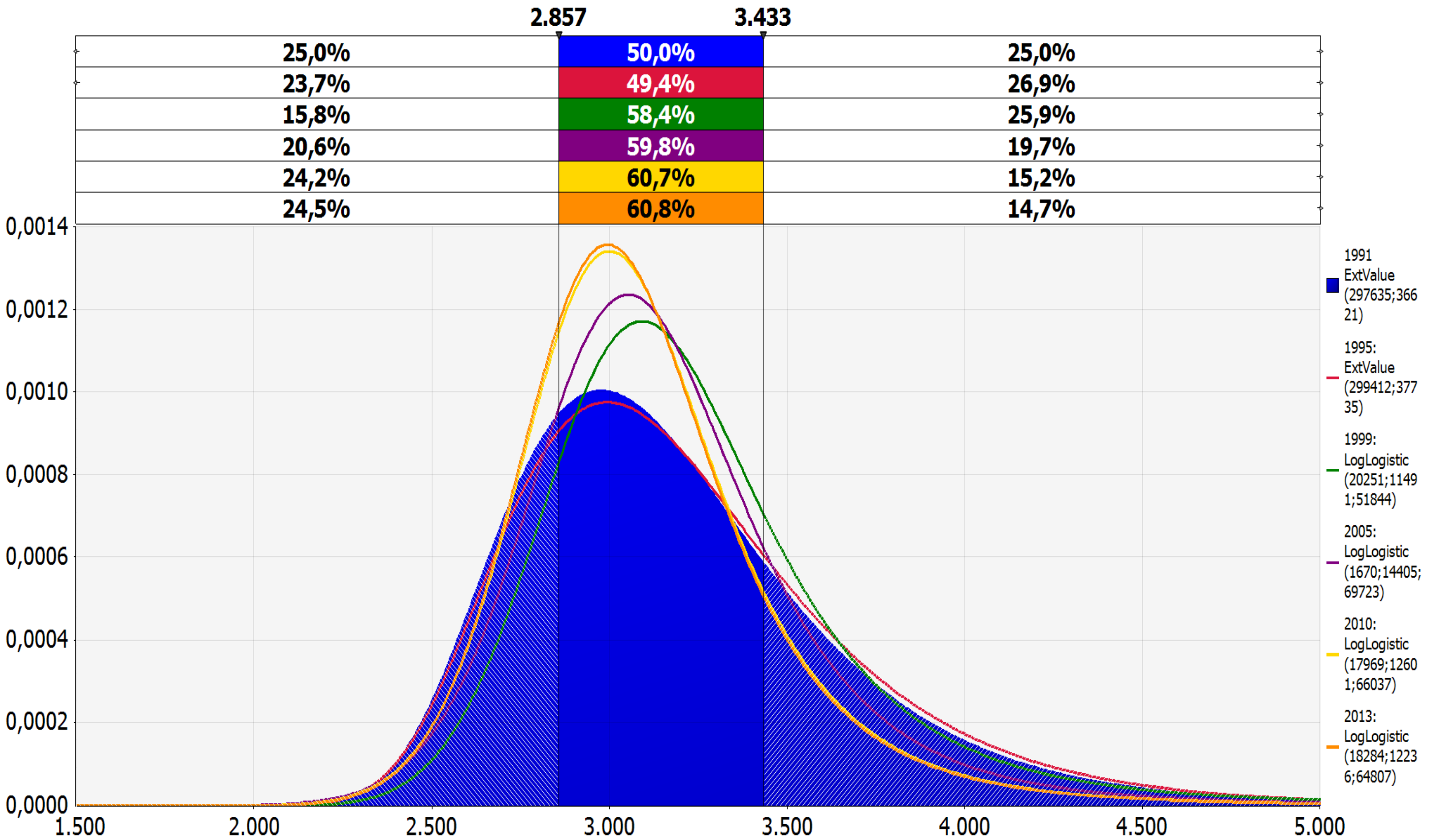
- **Changes in the use of resources and income are assessed for the entire study area and the 13 types of farm that represent its various agricultural segments.**

The climate changes obtained by comparing PDFs from *Current* and *Future* RAMS climate were consistent with the modifications that can be detected based on observed climatic data

Yields/HA of non-irrigated hay: PDFs under current RAMS (2000-2010) and future RAMS (2020-2030) scenarios



Yields/HA of non-irrigated hay: PDFs under climate data observed at different time intervals (1950-2013)



Each PDF is based on data of previous 30 years [i.e.: 1981 (1980-1951); 2010 (2009-1981)]

Productive and Economic results under Current RAMS climate and relative percentage change (%Δ) under Future RAMS climate

	Current		% Δ of Future over Current	
	Total area	*Hilly zone*	Total area	*Hilly zone*
Forage crops (000 ha)	32.5	*19.1*	-12.9	*-23.6*
Grain crops (000 ha)	13.5	*3.1*	34.4	*145.9*
Horticultural crops (000 ha)	6.5	*0.4*	0.0	*-0.1*
Residual Nitrogen (000 Ton)	9.8	*2.1*	4.2	*7.5*
Water use (Mmc)	117.6	*5.2*	-0.2	*3.0*
groundwater (Mm3)	*7.0*	*3.1*	*1.3*	*3.2*
Labor use (000 hours)	5.2	*1.3*	0.0	*0.6*
occasional (000 h)	*0.9*	*0.2*	*0.3*	*3.1*
Crop revenues (M€)	114.9	*11.2*	1.4	*12.1*
Livestock revenues (M€)	89.8	*14.5*	-1.1	*0.0*
Variable costs (M€)	129.2	*15.0*	2.4	*16.6*
livestock feeds(M€)	*22.2*	*3.2*	*5.7*	***59.5***
Gross income (M€)	107.2	*18.3*	-2.3	*-5.9*
Net income (M€)	78.9	*13.1*	-3.1	***-8.2***

Representative farms: net income under Current RAMS climate, and relative percentage change (%Δ) under Future RAMS climate

Representative farms	Farm dimension (ha)	Heads in Lactation	Net Income	
			Current (000 €)	Future (% variation)
Rice	115.3		170.7	**9.9**
Citrus fruits	12.6		39.3	0.0
Dairy farms A	30.9	110	202.8	**-5.1**
Dairy farms B	31.9	105	167.2	**-6.1**
Greenhouse	12.9		26.8	0.4
Mixed crops - Vegetables	22.2		33.2	-0.8
Mixed crops - Rice	146.4		89.1	**2.2**
Mixed crops - Field crops, trees	5.8		12.1	0.0
Mixed crops – Horticultural, trees	4.1		10.1	0.0
Mixed crops - Field crops	24.5		28.6	0.0
Sheep A	86.9	520	42.2	**-12.2**
Sheep B	41.2	350	10.1	**-17.6**
Sheep C	62.4	200	43.6	**-9.1**

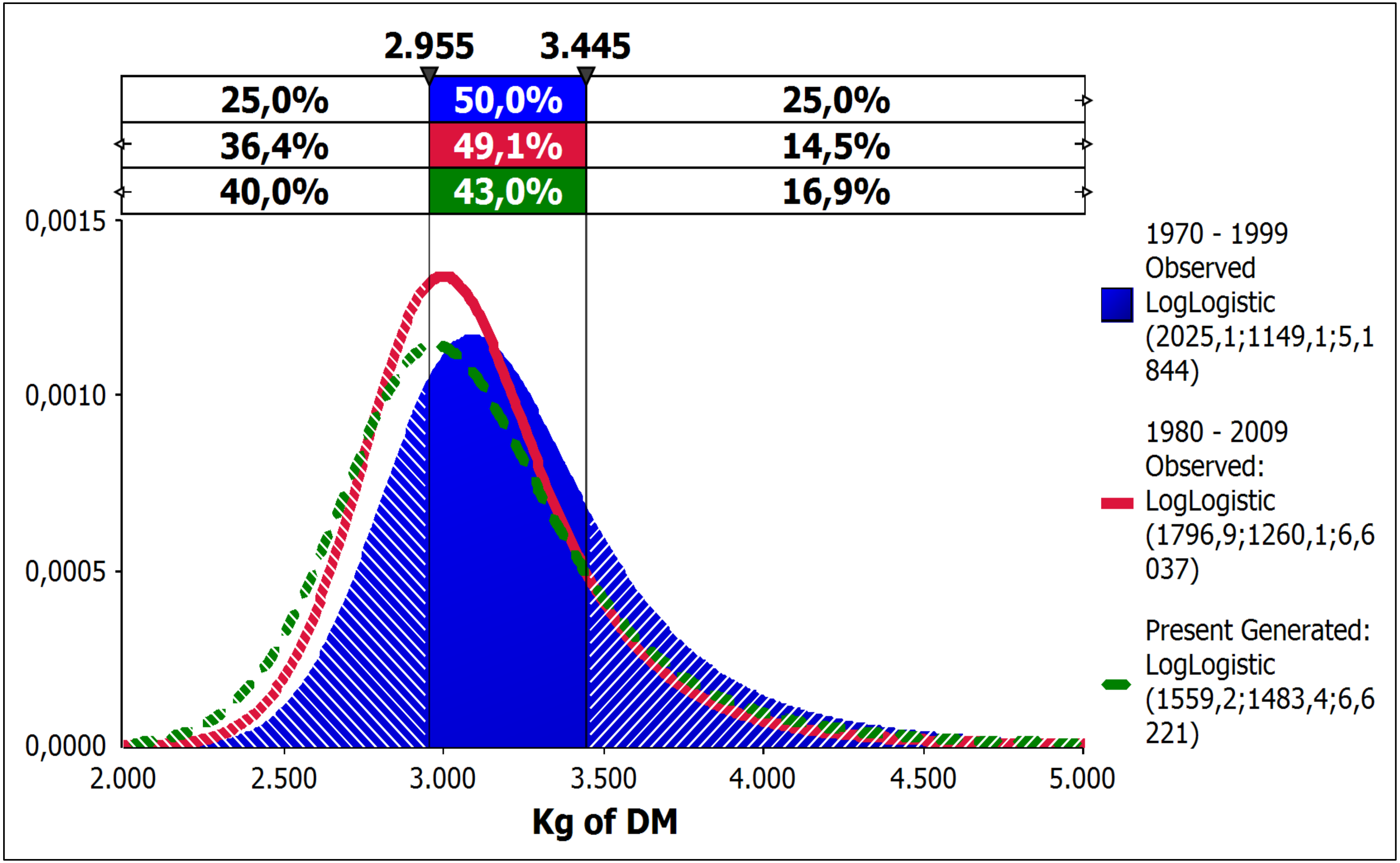
Part 3: actual cognition of farmers on climate

- **In simulating the impact of climate change it may be useful to consider that:**

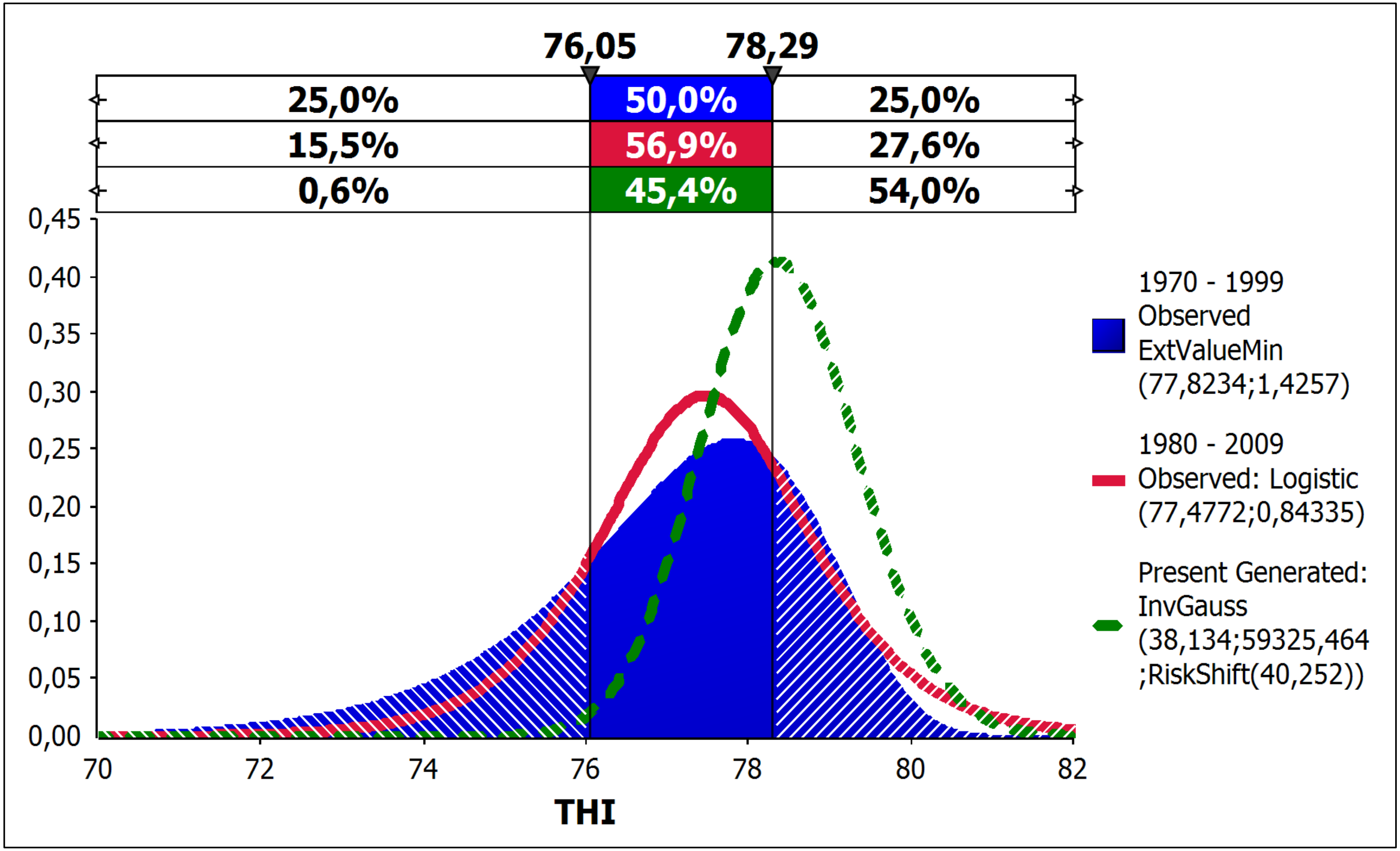
a) **It's not easy to understand that CC is ongoing, and farmers could interpret current climatic events as extreme manifestations of the past PDFs, actually assuming a substantial climatic stability;**

b) **Even assuming that CC is ongoing, based on few observations it's difficult to estimate the new PDFs resulting from an altered climate variability.**

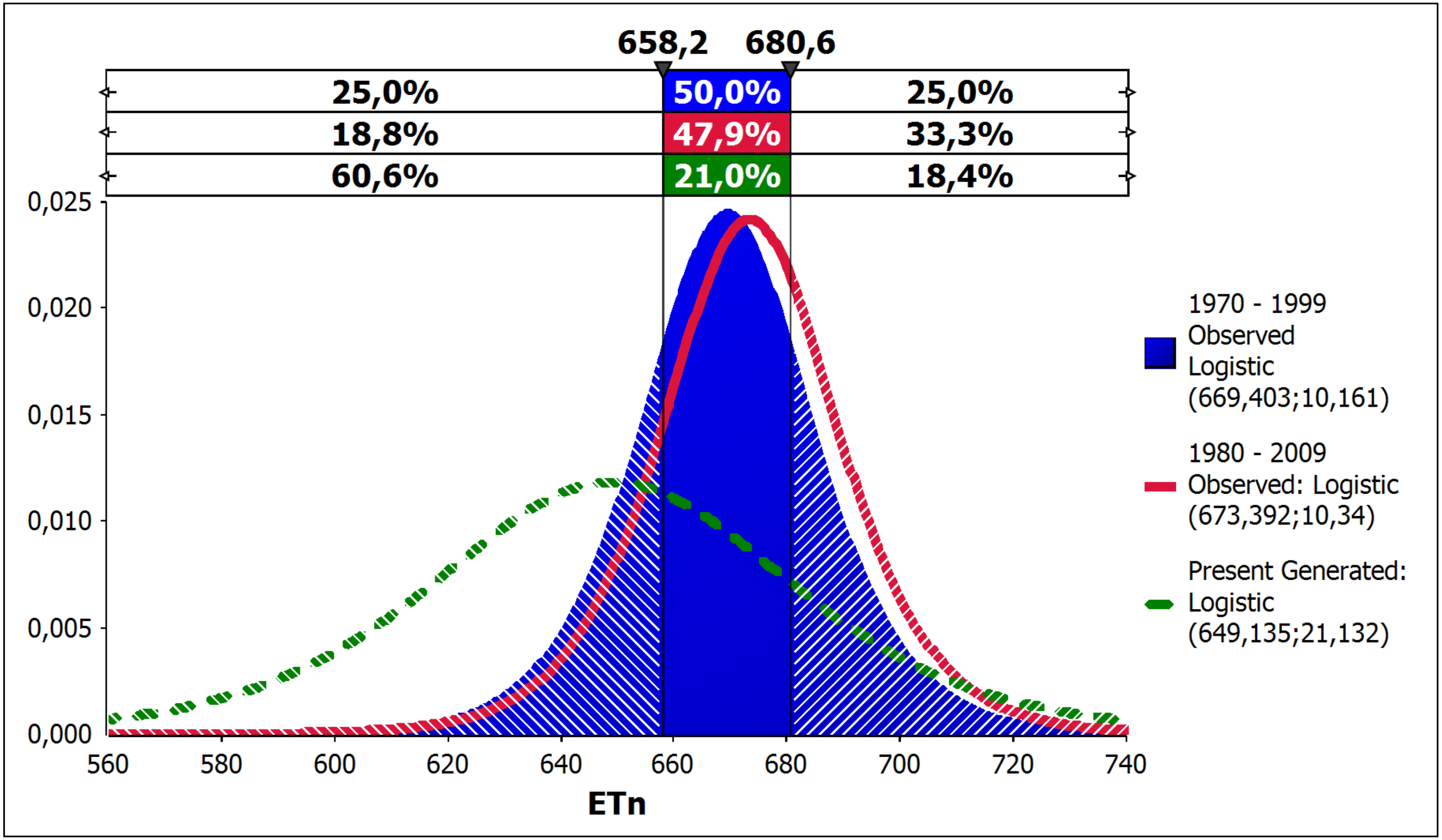
For some variables, observed (2000 and 2010) and RAMS scenarios generate coherent indications: yield/HA of non-irrigated hay



For other variables, observed (2000 and 2010) and RAMS scenarios generate coherent but insufficient indications: PDF of summer THI influencing dairy cows productive performances



For other variables, observed (2000 and 2010) and RAMS scenarios generate even incoherent indications: Summer Net Evapotranspiration influencing water needs of crops



Possible errors of assessment may be:

a. **not recognizing that CC is going on, or**
b. **not recognizing how CC is going on,**

and use farm resources assuming climate stability or incorrect new distributions of agro-climatic events.

Income impact of those errors assessed by comparing three hypotheses on the use of farm resources observed in 2010:

- **as generated by assuming stable climate at 2000,**
- **as generated by updating *pdfs* to climate observations up to 2010,**
- **As generated by using *pdfs* from our best knowledge (RAMS) on actual climate variability**

Different climate scenario: Net income (000 €) and percentage differences (Δ%).

	NI (000 €) under various climate scenarios			Δ % NI between scenarios		
	2000	2010	RAMS	2000 / RAMS	2010 / RAMS	2000 / 2010
Rice	4,091	4,093	4,097	-0.1	-0.1	0.0
Citrus fruits	2,670	2,670	2,670	0.0	0.0	0.0
Dairy farms A	26,161	26,068	26,355	-0.7	-1.1	0.4
Dairy farms B	6,568	6,550	6,825	**-3.8**	**-4.0**	0.3
Greenhouses	1,211	1,215	1,231	-1.6	-1.3	-0.3
Mixed crops - Vegetables	18,494	18,523	18,656	-0.9	-0.7	-0.2
Mixed crops - Rice	4,840	4,835	4,902	-1.3	-1.4	0.1
Mixed crops - Field crops and trees	1,176	1,187	1,209	**-2.7**	**-1.8**	-0.9
Mixed crops - Vegetables and trees	1,013	1,013	1,014	0.0	-0.1	0.1
Mixed crops - Field crops	2,678	2,681	2,691	-0.5	-0.4	-0.1
Sheep A	1,787	1,824	1,897	**-5.8**	**-3.9**	**-2.0**
Sheep B	1,947	1,965	1,894	**2.8**	**3.7**	-0.9
Sheep C	4,820	5,083	5,424	**-11.1**	**-6.3**	**-5.2**
WUA facilities	65,210	65,141	65,945	-1.1	-1.2	0.1
Rain-fed	12,246	12,567	12,920	**-5.2**	**-2.7**	**-2.6**
Total Area	77,456	77,708	78,865	-1.8	-1.5	-0.3

% changes in net income from adjustment to 2010 and RAMS climate

	2000 2010	2000 RAMS	2010 RAMS
Rice	0.1	0.3	0.2
Citrus fruits	0.0	0.0	0.0
Dairy farms A	0.1	**3.5**	**3.2**
Dairy farms B	0.5	**5.5**	**4.8**
Greenhouses	0.2	1.3	1.1
Mixed crops - Vegetables	0.4	2.1	1.5
Mixed crops - Rice	-0.1	2.9	2.9
Mixed crops - Field crops and trees	0.8	2.4	1.6
Mixed crops - Vegetables and trees	0.0	0.0	0.0
Mixed crops - Field crops	0.3	1.1	0.8
Sheep A	**4.0**	**14.4**	**10.2**
Sheep B	**2.7**	**10.4**	**7.5**
Sheep C	**1.5**	**6.3**	**4.6**
WUA facilities	0.2	2.8	2.5
Rain-fed	**1.7**	**6.5**	**4.7**
Total Area	0.4	3.4	2.8

- Even in a relatively short time, **appreciable climate changes are in place** that are relevant to agricultural activities. Non irrigated areas suffer more from not understanding the climate change that is on course.
- Failure to understand these changes can lead to **errors of planning**:
  - by preventing from taking advantage of existing opportunities;
  - by inducing farmers to **misconceptions on defence** from climate variability (negative results as outcome of occasional adversities and not as result of programming based on an inadequate framework of climate)
- Various types may appreciably increase income by modifying cropping systems under a better understanding of **actual** climate conditions
- Also planning the use of soil under updated PDFs of the climate events might appreciably increase the income of various farm types
- **An effective measure for adapting to CC might be supporting farmers in assessing the new and changing climate framework**

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THANK YOU FOR YOUR ATTENTION

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